Prepared for:

ALBERTA ENVIRONMENT

EARTH SCIENCES DIVISION - SOILS BRANCH

HYDROGEOLOGY OF THE HEMARUKA SITE

SUMMARY REPORT

A Site Evaluation for the

Proposed

SPECIAL WASTE MANAGEMENT FACILITY

Prepared by:

C.E. Moell, P.Geol.
A.M. Hingston, P.Geol.

C.E. MOELL & ASSOCIATES LTD.

TABLE OF CONTENTS

SECTION ONE - INTRODUCTION

1.1 Introduction 1
1.2 Location and Access 1

SECTION TWO - LAND SURFACE DESCRIPTION AND USE

2.1 Topography and Drainage 3
2.2 Land Use 3

SECTION THREE - GEOLOGY

3.1 Introduction 4
3.2 Surficial Geology 4
3.3 Bedrock Geology 4

SECTION FOUR - GROUNDWATER

4.1 Introduction 11
4.2 Watertable Depth and Configuration 11
4.3 Hydraulic Conductivity 12
4.4 Groundwater Velocity 13
4.5 Vertical Component of Groundwater Flow 16
4.6 Groundwater Resources 16

SECTION FIVE - SUMMARY AND CONCLUSIONS 18

SECTION SIX - RECOMMENDATIONS 23

LIST OF TABLES

Table 3.1: Particle Size Analysis - Test Hole No. 8 6
Table 3.2: Particle Size Analysis - Test Hole No. 29 . . . 9
Table 4.1: Distribution of Hydraulic Conductivity (K) Values 14

LIST OF FIGURES

Figure 1.1: Location and Access Plan 2
Figure 3.1: Test Hole Location Plan 5
Figure 3.2: Textural Variation With Depth - Test Hole No. 8 7
Figure 3.3: Textural Variation with Depth - Test Hole No. 29 8
Figure 3.4: Particle Size Distribution 10
Figure 4.1: Graphical Distribution of Hydraulic Conductivity (K) Values 15

SECTION ONE

INTRODUCTION

1.1 Introduction

A constraint mapping program conducted by Alberta Environment revealed an area near Hemaruka, Alberta as potentially suitable for development of a special waste management facility. A number of factors were considered during constraint mapping, but fundamental to the process was identifying areas where significant geologic/hydrogeologic constraints were absent. Published information indicates the area under consideration is mantled by fine-textured glacial drift, and that the bedrock subcrop consisted of Cretaceous-aged sediments of the marine-origin Bearpaw Formation. The Bearpaw is noted for its thick shale sequences, and for sandstone aquifers which characteristically yield limited quantities of poor quality groundwater. A quarter section of land was selected within the potentially constraint-free area for detailed investigation. This quarter, legally described as NW 28-33-8-W4M is located near the Hamlet of Hemaruka, and is referred to herein as the "Hemaruka Site".

This report represents a summary of the final hydrogeologic report prepared for the Hemaruka Site. The final report contains a greater level of detail, maps and cross-sections at a scale of 1:2000 and appended lithologic and hydrogeologic information collected during the investigation.

1.2 Location and Access

The Hemaruka Site is located in southeastern Alberta within Special Area 4. Access is by Secondary Road 884 (oiled) which connects Highway 12 (near Veteran) and Highway 9 (near Youngstown). The Hemaruka Site lies adjacent to Secondary 884 and entrance to the fenced property is by either of two gates from the Road (Figure 1.1).

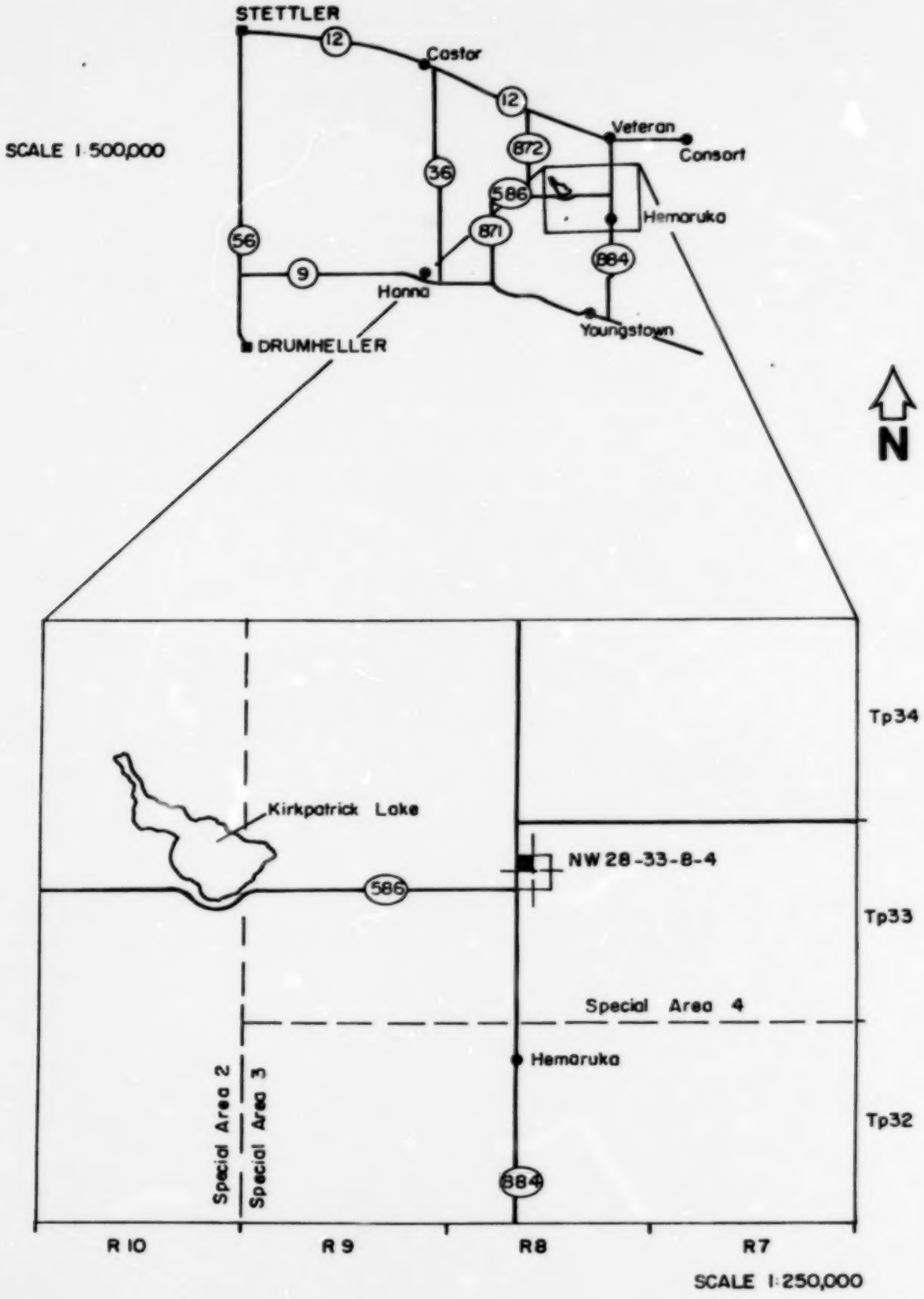


Figure 1.1 Location and Access Plan

SECTION TWO

LAND SURFACE DESCRIPTION AND USE

2.1 Topography and Drainage

The Hemaruka Site is located within a regional topographic trough trending northwest-southeast. The trough, possibly representing a glacial meltwater channel, is flat-bottomed and approximately 1.6 km wide; topographically higher ground trends across the southwestern boundary of the Hemaruka Site.

From a 1:2000 scale topographic map, relief on the Hemaruka Site totals 4 metres, ranging in elevation from 766.4 to 770.4 metres geodetic. Most of the property is flat, lying within the meltwater channel; topographic relief is provided only by a low ridge passing through the southwest corner of the site.

No drainage courses exist on the site. All surface water originating as precipitation collects in scattered sloughs and dugouts.

2.2 Land Use

The quarter boundaries are fenced north and west only; internal cross-fences are in place to separate pasture from cultivated areas. Thirty acres are presently in forage crops and the remaining land area serves as seasonal pasture.

SECTION THREE

GEOLOGY

3.1 Introduction

The geologic sequence to 18 metres below surface was investigated by drilling 25 dry auger test holes on a 200 metre grid. The sequence from 18 to 90 metres below surface was established through two rotary test holes. The locations of all test holes are indicated in Figure 3.1.

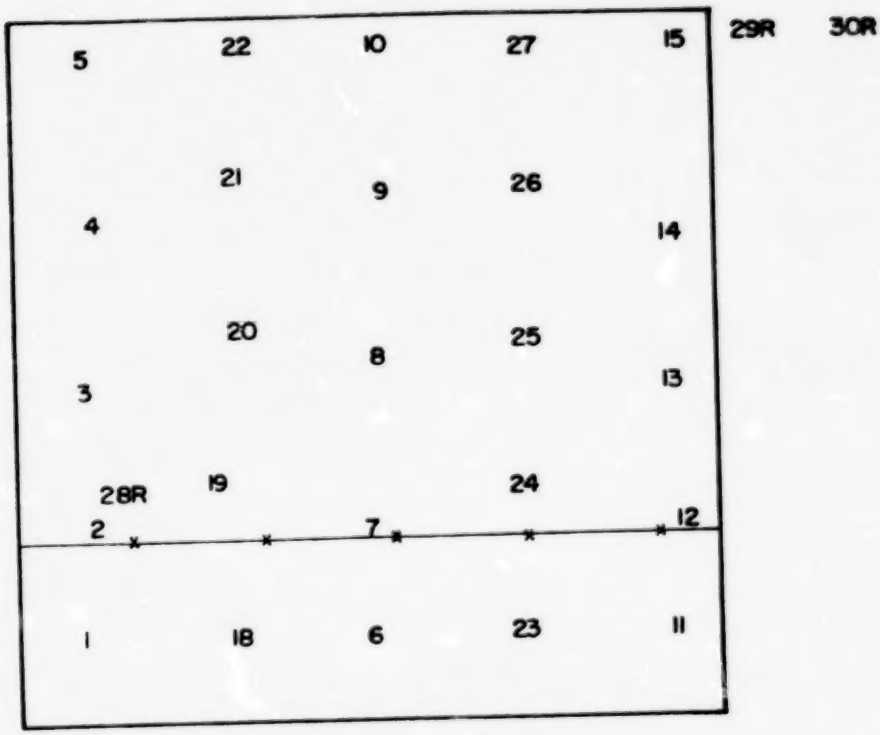
3.2 Surficial Geology

Surficial deposits over most of the Hemaruka Site consist of residual bedrock materials mixed with aeolian (wind-blown) deposits. The residual and aeolian materials form a veneer less than 0.5 metre thick over that part of the site lying within the flat-bottomed valley. A ridge crossing the southwest corner of the site consists of clay loam textured glacial till; the till is present to a maximum thickness of 5.5 metres, and is weathered (oxidized) nearly to the bedrock contact.

3.3 Bedrock Geology

Bedrock materials to a depth of 90 metres consist of a Cretaceous-age sedimentary sequence of silty shale, siltstone and argillaceous sandstone. The sediments are unconsolidated or weakly consolidated, and based on mineralogy and fossil fragments, are of marine origin (Bearpaw Formation) to the depth of investigation.

Figure 3.1 Test Hole Location Plan - Hemaruka Site



NOTES

1 Rotary holes denoted by R

2 Drill hole grid is 200m (approximate)

3 Map area denotes NW 28-33-8-4

4 ×——× denotes fence line

5 Drill holes 16 and 17 located along east boundary of N E 28

The stratigraphic sequence to a depth of 25 metres below the bedrock surface consists primarily of uniformly textured silty shale (silty clay loam, Table 3.1). Materials in this textural class contain little sand and approximately equal amounts of clay and silt. A plot of textural variation indicates the upper bedrock materials are very uniformly textured to a depth of 17 metres (Figure 3.2).

Particle size analyses, lithologic logs and resistivity logs indicate the upper silty shales continue to a depth of 25 metres (Figure 3.3). The first sandstone unit is encountered at this depth, although particle size analyses indicate the unconsolidated sandstone ranges texturally from sandy clay loam to clay loam with up to a maximum of 60% sand (Figure 3.3, Table 3.2). The uppermost sandstone is in the order of 17 metres thick. Materials underlying the upper sandstone consist of silty clay and silty clay loam-textured siltstone and shale (Table 3.2). A second sandstone unit lies at a depth of 77 metres (Figure 3.3). This unit is texturally similar to the upper sand and extends to greater than the 90 metre depth of investigation. The particle size range for all bedrock samples collected during the investigation are plotted in Figure 3.4.

Table 3.1: Particle Size Analysis - Test Hole No. 8

Sample No.	Depth (m)	Material	Texture
E8-1	1.0	Shale-weathered	Flocculated
2	1.5	Shale-weathered	CL
3	3.0	Shale-weathered	CL
4	4.5	Shale-dark grey	SiCL
5	6.0	Shale-dark grey	SiCL
6	7.5	Shale-dark grey	SiCL
7	9.0	Shale-grey-brown	SiC
8	10.5	Shale-grey-brown	SiCL
9	12.0	Shale-grey-brown	SiCL
10	13.5	Shale-dark grey	SiC
11	15.0	Shale-dark grey	C
12	16.5	Shale-dark grey	SiC

Legend

CL - Clay Loam
SiCL - Silty Clay Loam
SiC - Silty Clay
C - Clay

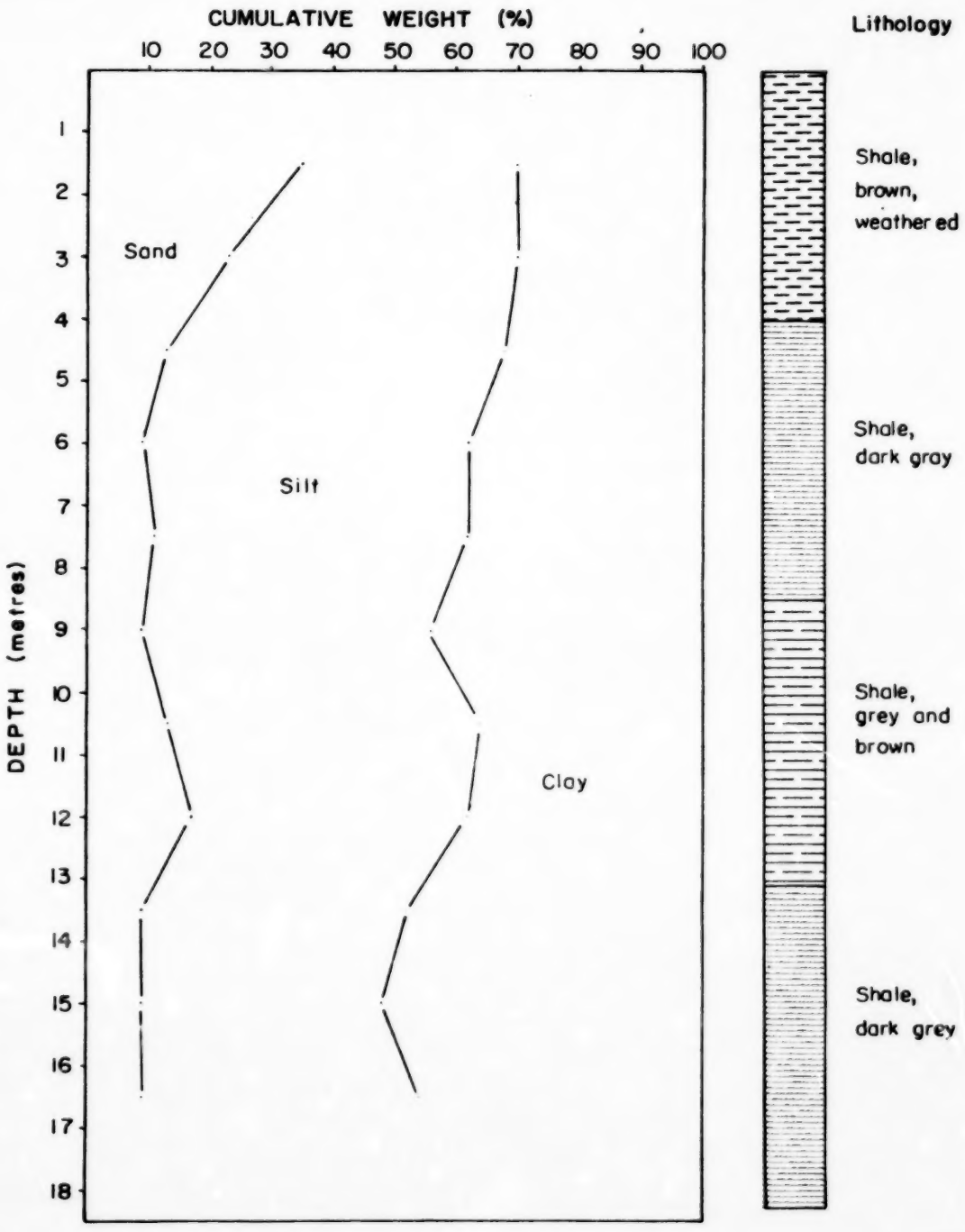

CUMULATIVE WEIGHT (%)
10 20 30 40 50 60 70 80 90 100
DEPTH (metres)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Sand
Silt
Clay
Lithology
Shale, brown, weathered
Shale, dark gray
Shale, grey and brown
Shale, dark grey

Figure 3.2 TEXTURAL VARIATION WITH DEPTH

TEST HOLE No. 8

Figure 3.3 TEXTURAL VARIATION WITH DEPTH

TEST HOLE No 29

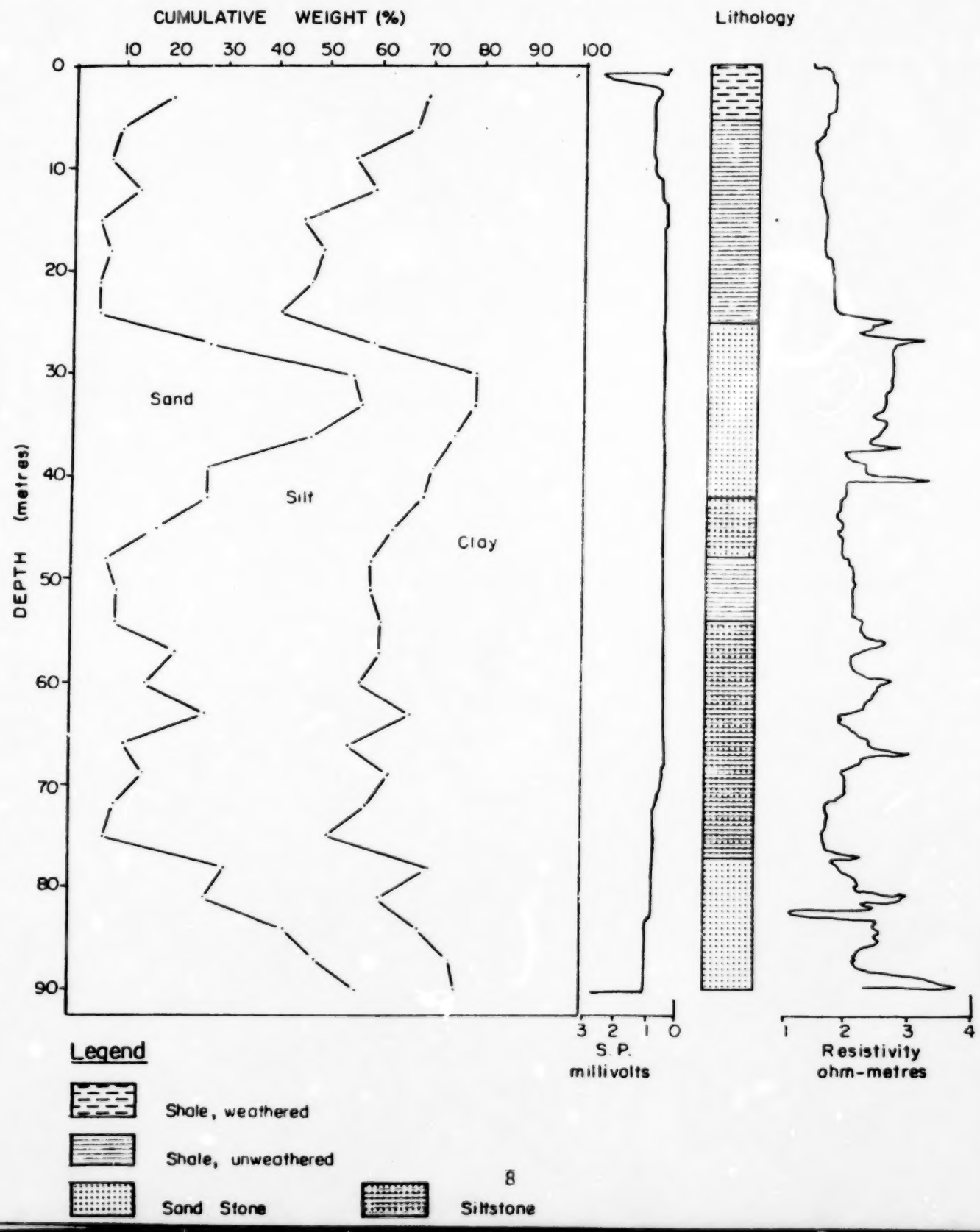


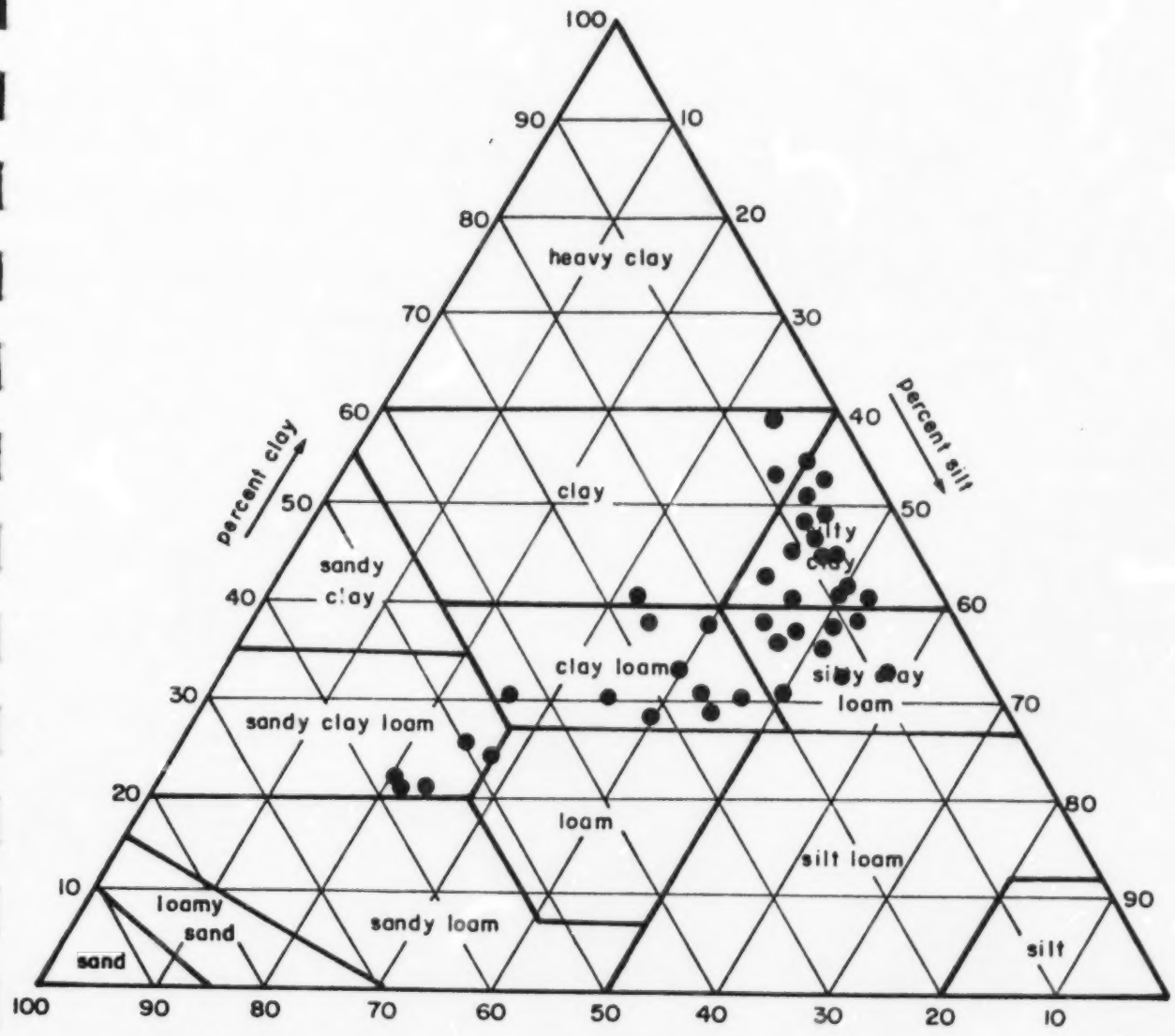
Table 3.2: Particle Size Analysis - Test Hole No. 29

Sample No.	Depth (m)	Material	Texture
E29- 1	3	Shale-weathered	SiCL
2	6	Shale-dark grey	SiCL
3	9	Shale-dark grey	SiC
4	12	Shale-dark grey	SiC
5	15	Shale-dark grey	C
6	18	Shale-dark grey	SiC
7	21	Shale-dark grey	SiC
8	24	Shale-dark grey	C
9	27	Sandstone, clayey	C
10	30	Sandstone, clayey	SCL
11	33	Sandstone, clayey	SCL
12	36	Sandstone, clayey	L
13	39	Sandstone, clayey	CL
14	42	Sandstone, clayey	CL
15	45	Siltstone	SiCL
16	48	Siltstone	SiC
17	51	Shale	SiC
18	54	Shale, sandy	SiCL
19	57	Siltstone	CL
20	60	Siltstone	SiC
21	63	Siltstone	CL
22	66	Siltstone	SiC
23	69	Siltstone	SiCL
24	72	Siltstone	SiC
25	75	Siltstone	SiC
26	78	Sandstone, clayey	CL
27	81	Sandstone, clayey	CL
28	84	Sandstone, clayey	CL
29	87	Sandstone, clayey	SCL
30	90	Sandstone, clayey	SCL

Legend

SiCL - Silty Clay Loam
SiC - Silty Clay
C - Clay
SCL - Sandy Clay Loam
L - Loam
CL - Clay Loam

Figure 3.4 Particle size distribution



Bearpaw Formation
N = 41 (bedrock samples)

Field	% samples in field
SCL	9.8
L	2.4
CL	22.0
SiCL	24.4
SiC	31.7
C	9.8

SECTION FOUR

GROUNDWATER

4.1 Introduction

Characteristics of the shallow groundwater system beneath the Hemaruka Site were investigated by installing a network of piezometers. A total of 85 piezometers were installed in 25 nests spaced 200 metres apart over the quarter section. Each nest contains three piezometers completed at the 6, 12 and 18 metre depths (below surface); a fourth piezometer completed at a depth of 4.5 metres was included at 10 of the 25 nests. Data obtained from the piezometer nests were used to determine watertable depth and configuration, hydraulic conductivity of geologic materials within which piezometers are completed, hydraulic gradients, and the horizontal and vertical components of groundwater flow.

The aquifer potential of a sandstone unit lying between 25 and 42 metres below ground level was investigated by installing a production-observation well pair at two locations on the property. Pumping tests were completed to determine aquifer characteristics and water samples obtained for chemical analysis. One set of wells were completed as permanent installations and the second pair was abandoned and cemented full length.

4.2 Watertable Depth and Configuration

The near-surface shale and till deposits contain a zone of groundwater saturation as a result of local infiltration of precipitation. This zone of saturation is commonly referred to as the watertable, and lies generally from 0.5 to 4.3 metres below surface. The watertable is shallowest beneath the flat lowland area which occupies most of the quarter, and is deepest beneath the topographically higher ridge bisecting the southwest corner of the property.

A contour map indicates the watertable slopes from southwest to northeast across the quarter. As is characteristic where near-surface sediments are of low permeability, the watertable surface is a close reflection of surface topography on the Hemaruka Site. Flow lines constructed perpendicular to the equipotential (contour) lines indicate groundwater at the watertable would be directed northeast. The mean hydraulic gradient from southwest to northeast is approximately 3.7×10^{-3}; the gradient is steeper than this value across the ridge in the southwest corner, and is nearly level across the flat lowland area.

4.3 Hydraulic Conductivity

The hydraulic conductivity (permeability) of subsurface materials was calculated from the results of single-well response tests on 68 piezometers. The number of tests at each of the 6, 12 and 18 metre depths total 23, 22 and 23 respectively.

The conductivity of shale at the 6 metre depth ranges from 9.4×10^{-8} to 1.8×10^{-5} cm/s, with a geometric mean (xg) of 3.0×10^{-7} cm/s. Twenty one of 23 values are in the range of 10^{-7} cm/s, indicating the shales at this depth are relatively impermeable. Two values in the order of 10^{-5} and 10^{-6} cm/s suggest fractures were intersected by the piezometer tips.

The incidence of fracturing appears to be greater at the 12 metre depth. Conductivity values range from 2.2×10^{-8} to 4.4×10^{-5} cm/s, with a geometric mean of 1.2×10^{-6} cm/s. Twelve of the 22 values available are in the order of 10^{-6} cm/s or greater, suggesting that fractures in the bedrock are a relatively frequent occurrence at this depth.

Piezometers completed at the 18 metre depth reveal hydraulic conductivity variations in the range of 1.2×10^{-8} to 3.2×10^{-5} with a geometric mean of 5.0×10^{-7} cm/s. Seven of 23 values are in the order of 10^{-6} cm/s or greater, indicating again that fracture intersection is a relatively frequent occurrence.

The values of hydraulic conductivity obtained from each piezometer are listed in Table 4.1, the frequency of each occurring value is graphically displayed for each of the three depths in Figure 4.1.

4.4 Groundwater Velocity

The mean linear velocity (V) of groundwater flow is governed by the intergranular hydraulic conductivity (K), the hydraulic gradient (dh/dl) and the porosity (N) in accordance with the following:

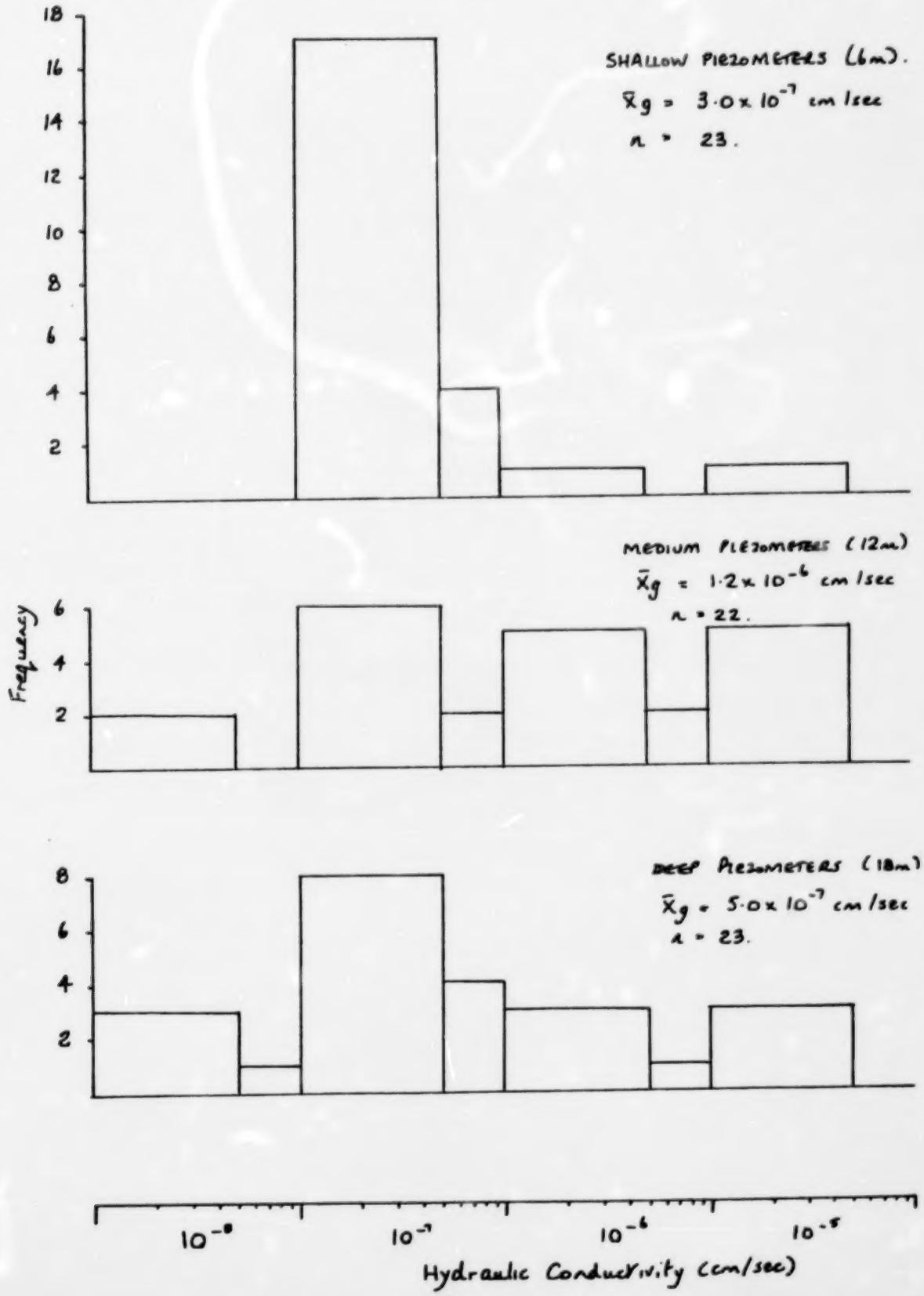
$$V = \frac{K \frac{dh}{dl}}{N} \qquad \text{(Equation 4.1)}$$

Assuming an effective porosity of 10%, a mean hydraulic gradient from the southwest to the northeast corners of the Hemaruka Site of 3.7×10^{-3}, and the range in hydraulic conductivity values obtained from the 6 metre depth, the mean linear groundwater velocity ranges from 11 cm/century to 21 cm/yr. When considering only the geometric mean value of hydraulic conductivity at the 6 metre depth and all other constraints held as above, the mean linear groundwater velocity is 35 cm/century.

Table 4.1: Distribution of Hydraulic Conductivity (K) Values

Shallow Piezometer (6 m)		Medium Piezometer (12 m)		Deep Piezometer (18 m)	
Piez. No.	K (cm/s)	Piez. No.	K (cm/s)	Piez. No.	K (cm/s)
1S	Insuff. Water	1C	Dry	1N	(1.2×10^{-8})
2C	5.9×10^{-7}	2N	Dry	Piez. at 30 m depth	
3S	1.4×10^{-6}	3C	1.3×10^{-5}	3N	2.5×10^{-7}
4S	9.7×10^{-7}	4C	4.8×10^{-8}	4N	3.2×10^{-5}
5S	1.3×10^{-7}	5C	6.8×10^{-7}	5N	(1.4×10^{-8})
6W	3.5×10^{-7}	6C	8.5×10^{-7}	6E	5.4×10^{-7}
7W	1.1×10^{-7}	7C	2.5×10^{-7}	7E	1.6×10^{-7}
8W	1.7×10^{-7}	8C	1.1×10^{-5}	8E	1.2×10^{-6}
9W	Dry	9C	Insuff. Water	9E	2.0×10^{-7}
10W	2.0×10^{-7}	10C	7.1×10^{-6}	10E	1.0×10^{-5}
11W	3.8×10^{-7}	11C	3.8×10^{-7}	11E	3.8×10^{-7}
12W	1.8×10^{-5}	12C	2.1×10^{-5}	12E	1.0×10^{-7}
13W	3.1×10^{-7}	13C	1.1×10^{-5}	13E	5.6×10^{-8}
14W	1.8×10^{-7}	14C	5.0×10^{-6}	14E	3.0×10^{-8}
15W	9.4×10^{-8}	15C	4.4×10^{-5}	15E	8.5×10^{-7}
18W	3.6×10^{-7}	18C	3.0×10^{-7}	18E	Insuff. Water
19W	1.8×10^{-7}	19C	(2.2×10^{-8})	19E	1.6×10^{-6}
20W	1.7×10^{-7}	20C	1.4×10^{-6}	20E	5.9×10^{-6}
21W	4.9×10^{-7}	21C	3.0×10^{-6}	21E	7.8×10^{-7}
22W	2.0×10^{-7}	22C	4.3×10^{-6}	22E	3.4×10^{-7}
23W	2.3×10^{-7}	23C	1.8×10^{-7}	23E	3.7×10^{-7}
24W	1.0×10^{-7}	24C	1.2×10^{-6}	24E	7.7×10^{-7}
25W	1.5×10^{-7}	25C	1.4×10^{-6}	25E	1.3×10^{-5}
26W	5.8×10^{-7}	26C	1.4×10^{-7}	26E	1.4×10^{-6}
27W	1.2×10^{-7}	27C	1.1×10^{-7}	27E	4.9×10^{-7}

Figure 4.1 GRAPHICAL DISTRIBUTION OF HYDRAULIC CONDUCTIVITY (K) VALUES



It should be noted that the above calculations are for flow through a porous medium; groundwater velocity through fracture systems may be several orders of magnitude greater than that calculated above, but there is no evidence that an extensive system of interconnected fractures exists in shales at the 6 metr depth.

4.5 Vertical Component of Groundwater Flow

Comparison of piezometric levels at the 6, 12 and 18 metre depths indicate generally that recharge conditions occur along topographically high areas in the southwest corner of the site, and that transitional or slight discharge gradients occur over the flat, low lying area characteristic of most of the property. The data indicate that groundwater flow is primarily horizontal, with a recharge (downward) gradient imposed only in the topographically higher area.

4.6 Groundwater Resources

The aquifer parameters of the first sandstone unit in the subsurface were evaluated by installation of two production-observation well pairs.

The first pair was located in the northeast corner of the site where the top of the 17 metre thick sandstone unit was located 25 metres below surface in a test hole.

A 120 minute constant-rate pumping test was conducted at a pumping rate of 327 m^3/d, and a drawdown of 1.76 metres from a static level of 4.4 metres was recorded in the production well. Aquifer parameters calculated include a transmissivity of 95 m^2/d, a storativity of 1.4×10^{-4} and a 20 year safe yield of 637 L/min (safety factor applied). The produced water is a sodium sulfate type with a TDS (total dissolved solids) of 2350 mg/L. The sodium and sulfate levels are 738 and 1230 mg/L respectively. Following testing the production and observation wells were abandoned and cemented full length.

A second production-observation well pair was installed near the southwest corner of the site. Both wells are partially cased and completed open-hole in the upper sandstone. A 24 hour pumping test at 178 m^3/d yielded 20 year safe yields in the range of 45 to 95 L/min from various portions of the drawdown and recovery curves. Safe yields based on data from the observation well are 127 (drawdown), and 113 L/min (recovery). No water samples were taken and both the production and observation wells were capped and left as permanent installations.

Wide variations in aquifer characteristics of the upper sandstone likely result from highly variable hydraulic conductivity characteristics from point to point in the aquifer. Based on regional hydrogeologic data the sandstone aquifer beneath the Hemaruka Site is a southeastward extension of a major aquifer underlying the Kirkpatrick Lake Area. The transmissivity variations noted during the present testing program are apparently characteristic of the aquifer underlying Kirkpatrick Lake.

SECTION FIVE

SUMMARY AND CONCLUSIONS

The subsurface geology beneath NW 28-33-8-4 (Hemaruka Site) was investigated by drilling 27 test holes, two of which extended to a maximum depth of 90 m.

Surficial soils consist of a thin veneer (less than 1 m thick) of aeolian and residual materials developed on glacial till or shale bedrock. The till is restricted to the southwest corner of the quarter where it forms a ridge and ranges in thickness up to 5.5 m thick. A weathering zone extends through the till to the underlying bedrock surface.

Bedrock deposits consist of silty shales to depths in the order of 25 m, and interbedded silty shales, siltstones and argillaceous sandstones from 25 - 90 m. Over much of the quarter, bedrock is encountered at the surface beneath a thin soil veneer. The sedimentary sequence is relatively soft and contains minor bands of indurated sediments in the order of several centimetres thick. The presence of glauconitic sands and marine invertebrate fossils indicate a marine origin for the full thickness of sediments investigated. Since subcrop in this region is mapped as the marine Bearpaw Formation, it is considered that Bearpaw sediments extend to depths greater than 90 m at the Hemaruka Site.

The hydraulic properties of geologic materials at three levels in the subsurface were determined by conducting response tests on piezometers. Piezometer nests were installed at 25 locations on the quarter, with three piezometers in each nest completed at 6, 12, and 18 m below surface.

The hydraulic conductivity of the stratigraphic sequence investigated is more variable at depth. Mean hydraulic conductivities (cm/s) for the three levels are 3.0×10^{-7} (six m depth), 1.2×10^{-6} (12 m depth), and 5.0×10^{-7} (18 m depth).

Conductivity values range over several orders of magnitude, from 10^{-5} to 10^{-8} cm/s at each of the three levels. Observations during test drilling coupled with high hydraulic conductivity values in the 10^{-5} - 10^{-6} cm/s range indicate that open fractures are likely intersected by some of the piezometer tips (of 68 tests conducted, nine yielded conductivity values in the order of 10^{-5} and 12 yielded values in the order of 10^{-6} cm/s). The data indicate that the incidence of fracturing appears to be relatively high.

The configuration of the watertable, as constructed by static measurements in the shallow (6 m depth) piezometers and watertable wells indicates groundwater flow from southwest to northeast beneath the Hemaruka Site. The general flow direction is locally influenced by topographic features, since the watertable configuration approximates the topographic configuration. The velocity of groundwater flow at the watertable is calculated at less than one m/century assuming a mean hydraulic gradient, mean hydraulic conductivity at the 6 m depth, and assuming flow is governed primarily by intergranular rather than fracture porosity.

The watertable depth beneath the Hemaruka Site ranges from 0.5 to 4.3 m below surface based on August, 1983 levels. The watertable is closest to the surface along the western and eastern portions of the quarter, and deepest beneath topographically higher areas along the southwest boundaries. It should be appreciated that groundwater at and beneath the watertable is contained by poorly pervious sediments which greatly restrict the velocity at which groundwater can flow. Sediments of this nature are termed aquitards or aquicludes, and viable water supply wells generally cannot be developed in such materials.

Rotary drilling and geophysical logging was conducted to depths of 90 m in order to determine the position of potential aquifers. Argillaceous sandstones were encountered at a depth of 25 m and contained significant quantities of groundwater. Pumping tests revealed a highly variable aquifer transmissivity, and calculations of safe yield are questionable under such conditions. Safe yields on the order of 100 L/min are indicated by test results, but the magnitude of this parameter may vary widely from point to point within the aquifer.

Given the existing hydrogeologic setting, the Hemaruka Site is suitable to development of a special waste management facility. Fine-grained, suitably-textured deposits persist from surface to a depth of 25 metres; vertical gradients are weak and indicate transitional or slight discharge gradients over most of the site with a recharge gradient beneath the topographically higher areas. An aquifer situated 25 meters below surface is protected by artesian pressures which preclude recharge from the surface.

Primary limitations which would potentially affect site suitability are three-fold, namely:

1) maintenance of the existing hydrogeologic setting,
2) watertable depth, and
3) presence of fractures.

The hydrogeologic setting of the Hemaruka Site may be subject to change over the long term, depending upon future groundwater demands on the underlying aquifer. Should the aquifer eventually be developed to the point where large-scale dewatering occurs, artesian pressures may be reduced to the point where recharge gradients predominate. In this eventuality, the risk of aquifer contamination is significantly greater should engineering containment measures fail, or should massive spills of reactive waste occur on the facility site. Site suitability is

dependent, therefore, on maintaining the existing hydrogeologic setting. If it is considered that the underlying aquifer cannot be managed to the degree required to preserve existing artesian conditions, then the Hemaruka Site should be considered unsuitable for development of a special waste management facility.

The second limitation to development is the watertable depth. As indicated previously the watertable lies at a relatively shallow depth beneath the topographically low plain occupying most of the quarter section. A high watertable is common in discharge or transitional areas, where upward or horizontal gradients prevent groundwater from draining to deeper levels. Since groundwater does not move downward, the potential for contaminating groundwater aquifers at depth is non-existent, except where artificially induced as indicated previously. The problems associated with a high watertable in discharge areas are more of an engineering nature. The construction of roads and foundations is generally more costly in areas where the watertable lies close to the surface, and the excavation and operation of a landfill site may require either temporary or permanent dewatering facilities. In view of the topographic setting of the Hemaruka Site, the watertable could not likely be lowered by gravity drains, and lift stations would likely be necessary to control groundwater levels in the vicinity of landfill excavations.

A third limitation is the presence of fractures indicated by values of hydraulic conductivity in the 10^{-5} - 10^{-6} cm/s range. Should an extensive and interconnected system of fractures exist in materials beneath the site, then the horizontal velocity may be considerably higher than that calculated. Given the existing hydrogeologic setting, the presence of fractures does not expose the underlying aquifer to a greater risk of contamination, owing to artesian conditions and discharge-transitional gradients in materials overlying the aquifer.

Should recharge gradients be artificially induced, however, an extensive interconnected system of fractures would greatly facilitate the downward movement of reactive or toxic materials released at the surface; in this instance the underlying aquifer would be exposed to a greater risk of contamination should spills or component failure result in dispersion of reactive or toxic substances beyond the engineered boundaries of the facility.

SECTION SIX

RECOMMENDATIONS

From a groundwater protection viewpoint, the Hemaruka Site is suitable to development of a special waste management facility provided the hydrogeologic setting as described in this report is not altered from present. The suitability of the site is dependent upon maintaining existing artesian pressures noted in the underlying aquifer, and discharge-transitional conditions in geologic materials over-lying the aquifer. It is recommended that the groundwater licensing authority be consulted as to the feasibility of maintaining the existing hydrogeologic setting, given present and projected demand on the underlying aquifer.

With regard to the watertable, it is our opinion that the position of the watertable presents no environmental hazard to development of a special waste management facility. High groundwater levels may interfere with the design and long-term operation of the facility. We would recommend that a design engineering firm be consulted with respect to potential problems associated with construction and operation of individual components of the facility, given the existing watertable level.

Fractures detected in the subsurface require engineering measures to ensure the integrity of containment features such as lagoons and landfill excavations. Fractures are common-place in Alberta, both in glacial and bedrock deposits, and are routinely dealt with in engineering designs. It is recommended that an engineering firm be consulted regarding the type of liners or construction practices required to eliminate the possibility of reactive or toxic substances from migrating via fracture systems beyond the engineered boundaries of the facility.

POOR

QUALITY

ORIGINAL